

19. Cumulative Impacts from Mining Activities to Biological Resources, Ecosystems, and Water Quality

IMPACT OF EROSION-TRANSPORTED OVERBURDEN DUMP MATERIALS ON WATER QUALITY IN LAKE COSPUDEN EVOLVED FROM A FORMER OPEN CAST LIGNITE MINE SOUTH OF LEIPZIG, GERMANY

Abel, A.; A. Michael; A. Zartl; F. Werner

Environmental Geology, Vol 39 No 6, p 683-688, 18 Apr 2000

Acidification is the most common water quality problem in lakes created from previous open cast lignite mines. Aeration of aquifers and dump materials from mining activities causes pyrite oxidation. Pyrite oxidation products are stored in pore water, minerals and at the exchange complexes of the aquifers and dump sediments. Rainfall runoff transports sediments on the dump slope into the lakes. Elutriation of these sediments within the lakes releases either acid-producing or acid-neutralizing agents. At a test site south of Leipzig, the annual erosion rates were quantified by water erosion models (RUSLE, EROSION 2D, PEPP) and field measurements. They ranged from 300 up to 900 tons per hectare. Hydrogen ion equivalent release or binding at the sediment elutriation was computed from laboratory analysis of the pore-water quality, ion exchange complex and mineral composition of the sediment. Two of the three investigated sediments contained 3 mmol (eq) acidity per 100 g dry sediment and revealed saturation with respect to jarosite, jurbanite and gypsum. In the third sediment, 6 mmol (eq) alkalinity per 100 g dry sediment was obtained. The annual net acidity influx was calculated to be about 0.5 million mol (eq) for the lake of the test site.

IMPACT OF MINING ACTIVITIES ON THE TERRESTRIAL AND AQUATIC ENVIRONMENT WITH EMPHASIS ON MITIGATION AND REMEDIAL MEASURES

Allan, R.J.

Heavy Metals: Problems and Solutions

Springer-Verlag, New York. ISBN: 3540585087. p 119-140, c1995

VEGETATION ON CONTAMINATED SITES NEAR AN HG MINE AND SMELTER

Banasova, V.

Mercury Contaminated Sites: Characterization, Risk Assessment, and Remediation

Springer, New York. ISBN: 3540637311. p 321-336, c1999

A WATERSHED-SCALE APPROACH TO TRACING METAL CONTAMINATION IN THE ENVIRONMENT

Church, S.E., U.S. Geological Survey, Denver, CO (schurch@usgs.gov)

Proceedings of the U.S. Geological Survey (USGS) Sediment Workshop, February 4-7, 1997

As a result of contamination from past mining operations, many stream reaches below old mines, mills, and mining districts and some major rivers and lakes no longer support aquatic life. Riparian habitats within these affected watersheds have also been impacted. Often, the water from these affected stream reaches is generally not suitable for drinking, creating a public health hazard. The Department of Interior Abandoned Mine Lands (AML) Initiative is an effort on the part of the

Federal Government to address the adverse environmental impact of these past mining practices on Federal lands. The AML Initiative has adopted a watershed approach to determine those sites that contribute the majority of the contaminants in the watershed. By remediating the largest sources of contamination within the watershed, the impact of metal contamination in the environment within the watershed as a whole is reduced rather than focusing largely on those sites for which principal responsible parties can be found. This paper is available at <http://water.usgs.gov/osw/techniques/workshop/church.html>

SOURCES OF GREATEST ACIDITY IN A COAL-MINED WATERSHED

Edwards, K.B.; Walter E. Grube, Jr.

Watershed Management Planning for the 21st Century: Proceedings of the Symposium, 14-16 August 1995, San Antonio, Texas

New York: ASCE. ISBN: 0-7844-0102-0, p 175-184, 1995

METAL CONCENTRATIONS IN SEDGES IN A WETLAND RECEIVING ACIDIC MINE DRAINAGE FROM ST. KEVIN GULCH, LEADVILLE, COLORADO

Erickson, B.M. (U. S. Geological Survey, Denver, CO); P.H. Briggs; T.R. Peacock

U.S. Geological Survey Toxic Substances Hydrology Program: Proceedings of the Technical Meeting, 20-24 September 1993, Colorado Springs, CO

U.S. Geological Survey Water-Resources Investigations 94-4015, p 797-804, 1996

ACID ROCK DRAINAGE AND RADIOLOGICAL ENVIRONMENTAL IMPACTS: A STUDY CASE OF THE URANIUM MINING AND MILLING FACILITIES AT POCOS DE CALDAS

Fernandes, H.M; M.R. Franklin; L.H. Veiga

Waste Management, Vol 18 No 3, p 169-181, 31 Jan 1998

Acid rock drainage generated as a result of sulfidic minerals oxidation is a source of pollution in many mining sites all around the world. This is the case at the uranium mining site of Pocos de Caldas, Brazil. The present study was aimed at studying the geochemical mechanisms involved on the mobilization of radionuclides from the waste rocks that occurs along with the acid drainage. The environmental radiological impacts caused by these pollutants were also assessed. It has been shown that precipitation of Ra and Pb as sulfates was the most important mechanism in the reduction of both radionuclides activity concentration in the acid drainage. A result of this study was that uranium isotopes were the most important radionuclides in terms of the exposure of the critical group. It has been suggested that the recovery of uranium from the acid drainage would be a feasible practice, economical aspects taken into account. It has also been estimated that pyrite oxidation will occur for more than a thousand years. The long time scale involved on the oxidation of the pyritic material implies the need for the adoption of permanent remedial actions. To assess applicable remediation strategies, it has been suggested that oxygen and temperature profile determinations should be carried out in the dump.

MERCURY MINES IN EUROPE: ASSESSMENT OF EMISSIONS AND ENVIRONMENTAL CONTAMINATION

Ferrara, R.

Mercury Contaminated Sites: Characterization, Risk Assessment, and Remediation
Springer, New York. ISBN: 3540637311. p 51-72, c1999

HYDROLOGIC ANALYSIS FOR ECOLOGICAL RISK ASSESSMENT OF WATERSHEDS WITH ABANDONED MINE LANDS

Gallagher, D.; J. Babendreier; D. Cherry

Proceedings of the ASCE-CSCE National Conference on Environmental Engineering, 25-28 July 1999, Norfolk, VA

ASCE, Reston, VA. ISBN: 0-7844-0435-6, p 463-470, 1999

IMPACT OF COAL PILE LEACHATE ON SURROUNDING SOIL AND GROUNDWATER

Ghuman, G.S.; M.E. Denham; K.S. Sajwan

Fourth International Conference on the Biogeochemistry of Trace Elements, University of California, Berkeley, p 15-16, 1997

MERCURY IN TERRESTRIAL FOOD WEBS OF THE IDRIJA MINING AREA

Gnamus, A.; M. Horvat

Mercury Contaminated Sites: Characterization, Risk Assessment, and Remediation
Springer, New York. ISBN: 3540637311. p 281-320, c1999

GEOCHEMICAL DATA FOR ENVIRONMENTAL STUDIES OF MERCURY MINES IN NEVADA

Gray, John E., et al.

U.S. Dept. of the Interior, U.S. Geological Survey, Denver, CO

U.S. Geological Survey Open-File Report 99-576. CD-ROM, 1999

This electronic file contains data from a 1999 environmental study to determine if weathering of abandoned mercury mines in Nevada has resulted in any significant effect to surrounding ecosystems.

MERCURY CONTAMINATION FROM HYDRAULIC PLACER-GOLD MINING IN THE DUTCH FLAT MINING DISTRICT, CALIFORNIA

Hunerlach, M.P.; J.J. Rytuba; C.N. Alpers

U.S. Geological Survey Toxic Substances Hydrology Program: Proceedings of the Technical Meeting, 8-12 March 1999, Charleston, South Carolina. Volume 2: Contamination of Hydrologic Systems and Related Ecosystems

U.S. Geological Survey Water-Resources Investigation Report 99-4018B, Vol 2, p 179-190, 1999

Elemental mercury (quicksilver) was used extensively for the recovery of gold at both placer and hardrock mines throughout the western United States. In placer mine operations, loss of mercury during gold recovery was reported to be as high as 30%. In the Dutch Flat mining district located in the Sierra Nevada region of California, placer mines processed more than 100,000,000 cubic yards of gold-bearing gravel. The placer ore was washed through mercury-charged ground sluices and drainage tunnels from

1857 to about 1900, during which time many thousands of pounds of mercury were released into the environment. Mine waters sampled in 1998 had total unfiltered mercury concentrations ranging from 40 ng/L (nanograms per liter) to 10,400 ng/L, concentrations of unfiltered methyl mercury ranged from 0.01 ng/L to 1.12 ng/L. Mercury concentrations in sluice-box sediments ranged from 600 µg/g (micrograms per gram) to 26,000 µg/g, which is in excess of applicable hazardous waste criteria (20 µg/g). These concentrations indicate that hundreds to thousands of pounds of mercury may remain at sites affected by hydraulic placer-gold mining. Elevated mercury concentrations have been detected previously in fish and invertebrate tissues downstream of the placer mines. Extensive transport of remobilized placer sediments in the Bear River and other Sierra Nevada watersheds has been well documented. Previous studies in the northwestern Sierra Nevada have shown that the highest average levels of mercury bioaccumulation occur in the Bear and South Fork Yuba River watersheds; this study has demonstrated a positive correlation of mercury bioaccumulation with intensity of hydraulic gravel mining. The paper is available at <http://toxics.usgs.gov/pubs/wri99-4018/Volume2/index.html>

WATER CONTAMINATION AND REMEDIAL MEASURES AT THE TROYA ABANDONED PB-ZN MINE (THE BASQUE COUNTRY, NORTHERN SPAIN)

Iribar, V.; F. Izco; P. Tames; I. Antigü; et al.

Environmental Geology, Vol 39 No 7, p 800-806, 15 May 2000

This article describes a case of contamination of a karstic aquifer by abandoning an underground mine exploiting sulphide ore body. To exploit the ore, the aquifer was drained and the water level declined about 230 m, drying up the spring that had drained the aquifer up to that moment. When the mining activity ceased, the piezometric level recovered and contaminated water began to flow out from a mine adit. The water is high in sulphates and dissolved Fe, although the pH is neutral. When this water reached the nearby creek, the fish population was eliminated, principally due to the presence of toxic metals and the precipitation of Fe hydroxides. The contamination originated in an area of the partially flooded mine rooms where the ore is in contact with both air and water. The acidity generated by pyrite oxidation is neutralized by calcite dissolution. Presently, the mine water is diverted to the old tailings pond which functions as an aerobic wetland. This action has allowed the fish population in the creek to be restored.

RUM JUNGLE MINE SITE REMEDIATION: RELATIONSHIP BETWEEN CHANGING WATER QUALITY PARAMETERS AND ECOLOGICAL RECOVERY IN THE FINNISS RIVER SYSTEM

Jeffree, R.A.; J.R. Twining (ANSTO, Menai, Australia); M.D. Lawton (Dept. of Lands, Planning and Environment, Palmerston, Australia)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO

Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 1, p 759-765, ©2000

The Finnis River system in tropical northern Australia has received acid-drainage contaminants from the Rum Jungle uranium/copper mine site over the past four decades. Following mine-site remediation that began in 1981-82 the annual contaminant loads of sulfate, Cu, Zn and Mn have declined by factors of 3, 7, 5 and 4, respectively over 1990-93, compared to the 1969-74 pre-remediation loads. Comparison of the frequency distributions of contaminant water concentrations over these pre- and post-remedial periods have shown varying degrees of reduction in the highest levels following mine-site remediation, that are consistent with reductions in their annual-cycle loads. Among the three selected major metal contaminants the reductions in maximum water concentrations are most pronounced for Cu. The demonstrated reductions in the highest water concentrations of all four

contaminants are also associated with previously reported ecological improvement in the Finnis River system, compared to the benchmark of environmental detriment established in 1973/74, prior to the beginning of remediation at the mine site.

EFFECTS OF HOLDEN MINE ON THE WATER, SEDIMENTS AND BENTHIC INVERTEBRATES OF RAILROAD CREEK (LAKE CHELAN)

Johnson, Art; Jody White; Dickey Huntamer

Washington State Dept. of Ecology, Env. Investigations and Lab. Services Program, Olympia, WA.

Publication no. 97-330. 57 pp, 1997

ENVIRONMENTAL CONSIDERATIONS OF ACTIVE AND ABANDONED MINE LANDS: LESSONS FROM SUMMITVILLE, COLORADO

King, Trude V.V. (ed.)

U.S. Geological Survey Bulletin 2220, 43 pp, 1995

There are between 100,000 and 500,000 abandoned or inactive mine sites in the United States; a total of 26 States, predominantly in the West, have more than 50 U.S. EPA Superfund restoration sites related to non-fuel mining activity. The Summitville mine site in Colorado is an example of what can go wrong. From 1985 through 1992, the Summitville open-pit mine produced gold from low-grade ore using cyanide heap-leach techniques, a method to extract gold low-grade ore using cyanide heap-leach techniques, a method to extract gold whereby the ore pile is sprayed with water containing cyanide, which dissolves the minute gold grains. Environmental problems at Summitville include significant increases in acidic and metal-rich drainage from the site, leakage of cyanide-bearing solutions from the heap-leach pad into an underdrain system (designed to catch solutions containing gold and cyanide that leaked through the liner under the heap), and several surface leaks of cyanide-bearing solutions into the Wightman Fork of the Alamosa River. The report is available at <http://greenwood.cr.usgs.gov/pub/bulletins/b2220/b2220.html>

ENZYMOLOGY OF DISTURBED SOILS

Kiss, S.; D. Pasca; M. Dragan-Bularda (eds.)

Elsevier, New York. ISBN: 044450057X. 336 pp, c1998

This book discusses the enzymology of soils disturbed by human activities such as mining. It contains chapters addressing soils affected by coal, lime, dolomite, manganese, sulfur, iron, apatite, phosphorite, lead, zinc, and gold mining wastes.

MERCURY CONTAMINATION FROM NEW WORLD GOLD AND SILVER MINE TAILING

Lacerda, L.D. de; W. Salomons

Mercury Contaminated Sites: Characterization, Risk Assessment, and Remediation

Springer, New York. ISBN: 3540637311. p 73-88, c1999

MERCURY FROM GOLD AND SILVER MINING: A CHEMICAL TIME BOMB?

Lacerda, Luiz D. de; Wim Salomons

Springer, New York. ISBN: 3540617248. 146 pp, c1998

REPRESENTATIVE PLANT AND ALGAL UPTAKE OF METALS NEAR GLOBE, ARIZONA

Marble, J.C.; T.L. Corley; M.H. Conklin

U.S. Geological Survey Toxic Substances Hydrology Program: Proceedings of the Technical Meeting, 8-12 March 1999, Charleston, South Carolina. Volume 1: Contamination From Hard-Rock Mining

U.S. Geological Survey Water-Resources Investigation Report 99-4018A, p 239-246, 1999

Past acid-mining activities in the Globe-Miami, Arizona area have resulted in the release of metal contaminants into the perennial reach of Pinal Creek. Dissolved manganese (Mn(II)) is the dominant metal with lower concentrations of dissolved zinc (Zn(II)), nickel (Ni(II)), copper (Cu(II)), iron (Fe(II,III)), and cobalt (Co(II)). In this study, uptake of metals by plants along the perennial reach of Pinal Creek was measured. Specifically, water speedwell (*Veronica anagallis-aquatica*), rabbitfoot grass (*Polypogon monspeliensis* (L.) Desf.), duckweed (*Lemna minor*), and algae (*Microcystis*, *Vaucheria*, and *Oocystis*) and moss were collected, digested, and analyzed for total Mn, Zn, Ni, Cu, Fe, and Co to determine the extent of bioaccumulation. Results indicate that bioaccumulation of these metals is occurring along the perennial reach of Pinal Creek with bioconcentration factors of 100 to over 10,000 depending upon the plant and the location along the reach. Comparisons with data from Pinto Creek, a nearby perennial creek with significantly lower metal concentrations, indicate that the bioconcentration factors are similar, but the mass of metals present in the aquatic plants at Pinal Creek is significantly higher. More Info:

<http://toxics.usgs.gov/pubs/wri99-4018/Volume1/index.html>

LITERATURE REVIEW REPORT: POSSIBLE MEANS OF EVALUATING THE BIOLOGICAL EFFECTS OF SUB-AQUEOUS DISPOSAL OF MINE TAILINGS

MEND Secretariat CANMET, Ottawa, Ontario. MEND Project 2.11.2a , Mar 1993

This review identifies promising geochemical and ecotoxicological approaches that might be used to monitor the biological effects of the sub-aqueous disposal of reactive mine tailings. Submerged mine tailings, and their constituent metals, may affect aquatic life in two ways: indirectly (i.e., by leaching of the metals into the ambient water, followed by their assimilation from the aqueous phase), and directly (e.g., in macrofauna, by ingestion of the tailings and assimilation of the metals from the gut). Both routes of metal exposure are considered. The metals that have been considered are those that are commonly present in reactive mine tailings, that are recognized as potentially toxic at low concentrations to aquatic biota, and that exist in natural waters as dissolved cations (e.g., Cd, Cu, Ni, Pb, Zn).

ECOLOGICAL POTENTIALS FOR PLANKTONIC DEVELOPMENT AND FOOD WEB INTERACTIONS IN EXTREMELY ACIDIC MINING LAKES IN LUSATIA

Nixdorf, B.; K. Wollmann; R. Deneke

Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation

Springer, New York. ISBN: 354063486X. p 147-168, c1998

EXPERIMENTAL DIVERSION OF ACID MINE DRAINAGE AND THE EFFECTS ON A HEADWATER STREAM

Niyogi, D.K. (Univ. of Colorado, Boulder); D.M. McKnight; W.M. Lewis, Jr.; B.A. Kimball

U.S. Geological Survey Toxic Substances Hydrology Program: Proceedings of the Technical Meeting, 8-12 March 1999, Charleston, South Carolina. Volume 1: Contamination From Hard-Rock Mining

U.S. Geological Survey Water-Resources Investigation Report 99-4018A, p 123-130, 1999

An experimental diversion of acid mine drainage was set up near an abandoned mine in Saint

Kevin Gulch, Colorado. A mass-balance approach using natural tracers was used to estimate flows into Saint Kevin Gulch. The diversion system collected about 85 percent of the mine water during its first year of operation (1994). In the first 2 months after the diversion, benthic algae in an experimental reach (stream reach around which mine drainage was diverted) became more abundant as water quality improved (increase in pH, decrease in zinc concentrations) and substrate quality changed (decrease in rate of metal hydroxide deposition). Further increases in pH to levels above 4.6, however, led to lower algal biomass in subsequent years (1995-97). An increase in deposition of aluminum precipitates at pH greater than 4.6 may account for the suppression of algal biomass. The pH in the experimental reach was lower in 1998 and algal biomass increased. Mine drainage presents a complex, interactive set of stresses on stream ecosystems. These interactions need to be considered in remediation goals and plans. More Info: <http://toxics.usgs.gov/pubs/wri99-4018/Volume1/index.html>

GEOCHEMISTRY, TOXICITY, AND SORPTION PROPERTIES OF CONTAMINATED SEDIMENTS AND PORE WATERS FROM TWO RESERVOIRS RECEIVING ACID MINE DRAINAGE

Nordstrom, D.K.; C.N. Alpers; J.A. Coston; H.E. Taylor; R.B. McCleskey; J.W. Ball; Scott Ogle; J.S. Cotsifas; J.A. Davis

U.S. Geological Survey Toxic Substances Hydrology Program: Proceedings of the Technical Meeting, 8-12 March 1999, Charleston, South Carolina. Volume 1: Contamination From Hard-Rock Mining

U.S. Geological Survey Water-Resources Investigation Report 99-4018A, p 289-296, 1999

Acid mine waters from the Iron Mountain Superfund Site, Shasta County, California, flow through Spring Creek Reservoir and into Keswick Reservoir on the Sacramento River. In Keswick Reservoir, the acid mine waters have neutralized on mixing with neutral-pH lake water, producing fine-grained, metal-rich sediments. Sediment cores were collected during 1997 from both reservoirs for characterization and pore waters were extracted under anoxic conditions. Chemical composition, mineralogical identification, redox chemistry, sorption properties, and toxicity were determined on several samples. Metal concentrations in sediment ranged from 4 to 47 % for Fe, 200 to 4,800 mg/kg (milligrams per kilogram) for Cu, and 85 to 6,600 mg/kg for Zn. Pore waters ranged in pH from 4.7 to 6.7 and their Fe(II) concentration range was 10 to 2,000 mg/L (milligrams per liter). Although pore-water Zn concentrations ranged from 0.1 to 9 mg/L, Cu concentrations were less than 0.01 mg/L.

Considerable reductive iron dissolution has occurred in the Keswick Reservoir sediments, but there is little or no indication of sulfate reduction. Adsorption and desorption experiments for Cu, Zn, and Cd on composite sediment samples demonstrated typical sorption behavior for metal ions on iron oxides, except that the adsorption edge is moved about one pH unit lower than expected compared to a hydrous ferric oxide substrate, but similar to that for a schwertmannite (ferric oxyhydroxysulfate) substrate.

Schwertmannite was identified in the sediments by x-ray diffraction and Mössbauer spectroscopy. Toxicity tests, using dilutions of Keswick sediment pore waters and *Ceriodaphnia dubia* as a test animal, demonstrated that iron is the causative agent for both acute and chronic toxicity with a minor contribution to toxicity from zinc. More Info: <http://toxics.usgs.gov/pubs/wri99-4018/Volume1/index.html>

WATER QUALITY AT INACTIVE AND ABANDONED MINES IN NEVADA: REPORT OF A COOPERATIVE PROJECT AMONG STATE AGENCIES

Price, Jonathan G., et al., for the Western Governor's Association

Nevada Bureau of Mines and Geology, Mackay School of Mines, Univ. of Nevada, Reno, NV. 71 pp, 1995

ENVIRONMENTAL EFFECTS OF MINING

Ripley, Earle A.; R.E. Redmann; A.A. Crowder, Univ. of Saskatchewan

CRC Press, Boca Raton, FL. ISBN: 188401576X. 356 pp, 1995

This book covers the environmental effects of mining activities and their resulting impacts on organisms and ecosystems. Examples used in this in-depth study can be applied to environmental situations worldwide. Covers mineral production and its environmental effects, the ecosystems, protection, reclamation, and rehabilitation, sulphide ores, gold and silver, uranium, iron ore, carbon products, and potash and other salts, and industrial chemicals. It also describes contemporary methods for damage prevention and restoration for both new, older, and abandoned sites.

ABANDONED MINES AND NATURALLY OCCURRING ACID ROCK DRAINAGE ON NATIONAL FOREST SYSTEM LANDS IN COLORADO

Sares, M.A.; J.T. Neubert (Colorado Geological Survey, Denver, CO); D.L. Gusey (U.S. Forest Service, Lakewood, CO)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO

Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1361-1370, ©2000

The Colorado Geological Survey completed an inventory of environmental degradation associated with abandoned and inactive mines on National Forest System lands in Colorado. Areas with naturally occurring acid rock drainage were also noted. Approximately 18,000 abandoned mine-related features were inventoried, including about 900 features that are considered significant enough environmental problems to warrant further investigation. Water quality data, such as pH and conductivity were gathered at all features where water was present. Samples were taken where field tests indicated low pH and and/or high conductivity. Samples were analyzed for dissolved and total metals, and for selected anions. All mine locations and data were entered on field forms and into a computer database and GIS format. With this information, the Forest Service, in cooperation with other agencies, has been able to prioritize abandoned mines for reclamation. In most cases, cleanup is approached on a watershed basis. Mines in priority watersheds have been selected for reclamation first.

MICROBIOLOGICAL PYRITE OXIDATION IN A MINE TAILINGS HEAP AND ITS RELEVANCE TO THE DEATH OF VEGETATION

Schippers, Axel; P.-G. Jozsa; W. Sand; Z.M. Kovacs; M. Jelea

Geomicrobiology, Vol 17 No 2, p 151-162, Apr 2000

The oxidation of pyrite in a mine tailings heap in Romania was studied to clarify the contribution of acid drainage to the death of vegetation on the eastern slope of the tailings. Where vegetation died, pyrite oxidation was detected as deep as 1 m, as indicated by the brownish color of the samples. At these sites *Thiobacillus ferrooxidans*-like bacteria were present with cell counts of 10^3 g and *Thiobacillus thiooxidans*-like bacteria occurred with cell counts of 10^4 g. At the western slope, where vegetation thrived, cell counts of $< 10^4$ g were measured. Correspondingly, leaching activity and concentrations of pyrite oxidation products such as sulfate and elemental sulfur were markedly higher on the eastern slope than on the western slope. These differences were mainly a result of the high acid neutralization potential in the material from the western slope, which kept the pH in a neutral range allowing for plant growth. In contrast, on the eastern slope with its low acid neutralization potential, the pH dropped to 3 to 4, increasing the solubility of phytotoxic elements. The death of the vegetation could result from the lowered pH and the increased amount of toxic elements, or, most likely, a combination of these factors.

PHYTOPLANKTON COMPOSITION AND BIOMASS SPECTRA CREATED BY FLOW
CYTOMETRY AND ZOOPLANKTON COMPOSITION IN MINING LAKES OF DIFFERENT
STATES OF ACIDIFICATION

Steinberg, C.E.W.; H. Schafer; J. Tittel, et al.

Acidic Mining Lakes: Acid Mine Drainage, Limnology, and Reclamation

Springer, New York. ISBN: 354063486X. p 127-146, c1998

CONTAINMENT OF MOBILE METALS IN NATURAL WETLAND SYSTEMS. STUDIES OF
SEMI-NATURAL WETLAND MESOCOSMS WITH SUB-SURFACE FLOW

Stoddern, T.J.; L.E.T Jenkin; D.C. Watkins; K. Atkinson

Sudbury '99: Mining and the Environment II, Sudbury, Canada. p 703-710, 1999

MERCURY-CONTAMINATED INDUSTRIAL AND MINING SITES IN NORTH AMERICA: AN
OVERVIEW WITH SELECTED CASE STUDIES

Turner, R.R.; G. R. Southworth

Mercury Contaminated Sites: Characterization, Risk Assessment, and Remediation

Springer, New York. ISBN: 3540637311. p 89-112, c1999

DAMAGE CASES AND ENVIRONMENTAL RELEASES FROM MINES AND MINERAL
PROCESSING SITES

U.S. EPA, Washington, DC. Office of Solid Waste and Emergency Response

NTIS: PB99-155988. 290 pp, Apr 1998

In its continuing efforts of collecting information on the mining and mineral processing industry, EPA obtained detailed information to develop approximately 62 summaries illustrating recent mining and mineral processing damage cases in a variety of mineral commodity sectors and states. While these cases should not be viewed as the results of an exhaustive survey or as a statistically representative body of knowledge, EPA does believe they demonstrate that releases of constituents to the environment with consequent environmental damages have been and are occurring from many different types of mineral production sites and activities across the U.S. A table provides summary information on the cases of documented damages and contaminant releases described in this report. Additional detail on the specific facility can be found in the body of the report. In the accompanying tables, the cases are organized according to the primary mineral commodity sectors involved. In addition, the table describes the general source of constituent releases, and provides supporting information on the nature and severity of any resulting environmental damages.

ACID ROCK DRAINAGE FROM ABANDONED MINES TO HIGH-ANDEAN LAKES

Vidalon, J.A. (Ministry of Energy and Mines, Lima, Peru); J.A. Rios (Universidad Nacional Agraria La Molina, Lima, Peru)

Fifth International Conference on Acid Rock Drainage, 20-26 May 2000, Denver, CO

Society for Mining, Metallurgy, and Exploration, Inc. (SME), Littleton, CO. ISBN: 0-87335-182-7. Vol 2, p 1403-1414, ©2000

The case study of a highland area in the Central Andes of Peru, where many abandoned

polymetallic mines are found, is presented. Some of these mines generate metal leaching and acid rock drainage (ML-ARD) or have potentially ARD generating (PAG) tailings/waste rock storage. Effluents are discharged into the first of two lakes in line, which act as reservoirs for irrigating an important valley in the desert coastal region. Drainage features, their relationship with the deposit and the solid-wastes mineralogy are discussed, as well as variations in water and sediments composition, the benthos, and the aquatic/riparian flora/fauna in these lakes.

EFFECTS OF SURFACE MINING ON THE HYDROLOGY AND BIOLOGY IN THE STONY FORK BASIN, FAYETTE COUNTY, PENNSYLVANIA, 1978-85

Williams, D.R.; J.R. Ritter; T.M. Mastrilli; T. Proch

USGS Water-Resources Investigations Report 94-4056, 33 pp, 1995

The effects of surface coal mining on the water quality, sediment discharge, and aquatic biology of streams in the Stony Fork Basin in southwestern Pennsylvania were studied from 1978 through 1985. Data were collected at five stream sites and one mine discharge site. Field data included stream- flow, temperature, specific conductance, pH, acidity, and alkalinity. Laboratory analyses included sulfate, aluminum, iron, manganese, zinc, and selected trace elements. Annual streamflow at gaged sites was not substantially different, suggesting that mining did not affect the total volume of streamflow significantly. Comparisons of sediment yields of the upstream control site (site 5) to the downstream site (site 1) indicated that the sediment yield at site 5 was greater in 1978, 1981-83, and 1985. The sediment yields at both sites in 1979-80 were about the same. Differences in the drainage area sizes and effective control of sediment in the mined areas may explain the lack of increased sediment yield at the downstream site. As mining became more extensive throughout the basin in 1979-80 and later, several water-quality effects were observed downstream. Generally, specific conductance, sulfate, manganese, aluminum, and zinc increased; pH and alkalinity decreased. Acidity and iron typically increased immediately downstream of mined areas. No trace-element concentrations exceeded maximum contaminant levels established by the U.S. Environmental Protection Agency. Surface mining in the Stony Fork Basin severely affected the stream invertebrate and fish populations. Between 1977 and 1984, the number of taxonomic groups of invertebrates at sites affected by mine drainage decreased by 45 to 71 percent; the number of fish species decreased by 81 to 88 percent.